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THE Be-Zn (BERYLLIUM-ZINC) SYSTEM

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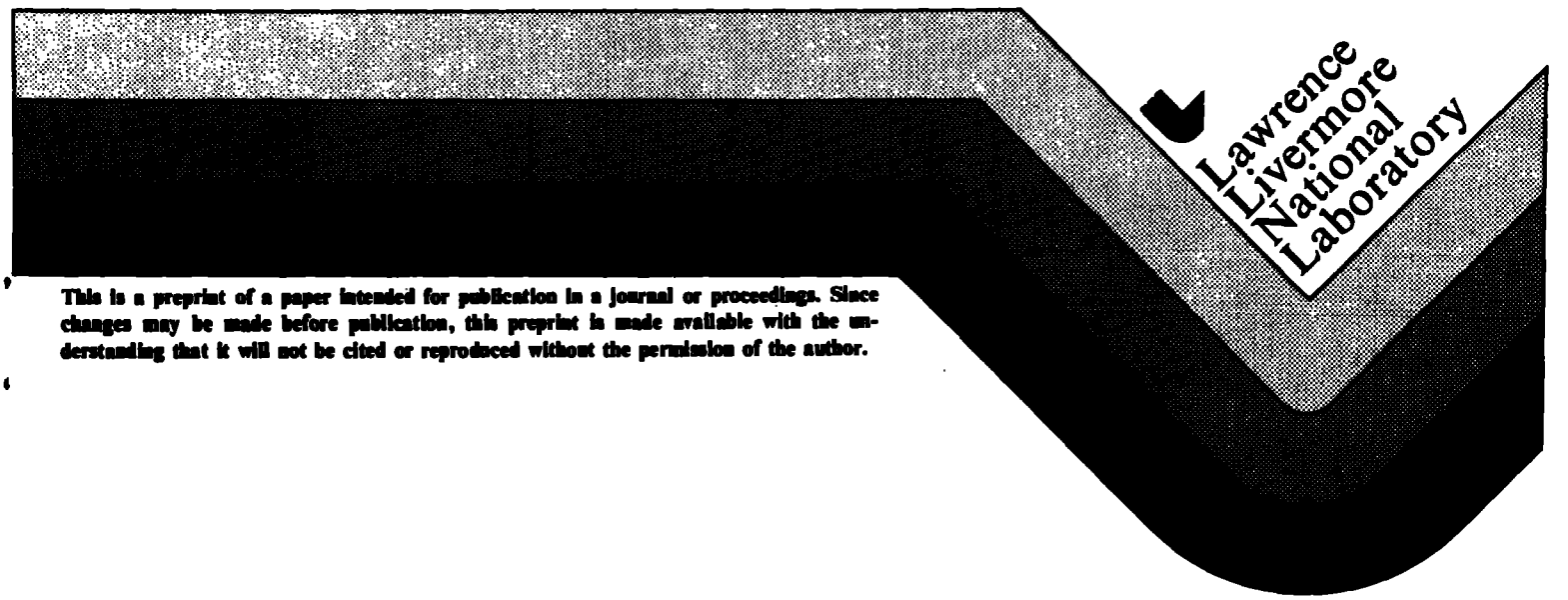

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The Be-Zn (Beryllium-Zinc) System

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Equilibrium Diagram

The limited data for the Be-Zn system [62Joh] showed strong similarities to the Be systems with Ga, In, Sn and Bi; [85Oka1, 85Oka2, 85Oka3, 85Oka4] suggested the existence of extensive liquid immiscibility and a monotectic reaction at elevated temperatures, though critical temperatures and compositions are not known.

A eutectic-type structure was observed at the interface of Be and Zn when sintered at 600 to 700 °C [64Wen]. This suggests a eutectic reaction in proximity to the Zn-rich end of the assessed phase diagram in Fig. 1. The liquidus trend near the eutectic has been used to model the liquid immiscibility (see "Thermodynamics" section).

There are no intermediate phases in this system [60Yan, 61Nic, 64Wen].

(βBe) and (αBe) Terminal Solid Solutions. The melting point of βBe and the βBe —> αBe allotropic transformation temperature are 1289±4 and 1270±6 °C, respectively [85BAP]. The solubility of Zn in Be is small; only 0.08 at.% was detected in liquid Be [50Kau]. Lattice parameter measurements did not reveal Zn solubility in solid Be [60Yan].

(Zn) Terminal Solid Solution. The melting point of Zn is 419.58 °C [Melt]. The boiling point of Zn (906 °C) is lower than the melting point of Be, which made the investigation of the Be-Zn system difficult [62Jor]. [62Joh] measured the solubility of Be in liquid Zn using the sampling method (Table 1).

Table 1 Solubility of Be in Liquid Zn (Liquidus) [62Joh]

Temperature, °C	Composition, at.% Be
696	0.58
630	0.435
611	0.389
571	0.274
512	0.149
486	0.11
453	0.134
429	0.0465

These values were expressed by [62Joh] as $\ln X = 2.788 - 7444/T$, where X is the mole fraction of Be and T is in K. Similar results were obtained by emf measurements by [68Dub] as $\ln X = 1.842 - 6781/T$ (Fig. 2). The eutectic composition is about 0.04 at.% Be according to Fig. 2. The eutectic temperature is about 0.2 °C lower than the melting point of Zn (see "Thermodynamics" section).

[61Nic] reported that 23 at.% Be can be dissolved in liquid Zn, from experiments involving deposition of molten Be salt on a molten Zn cathode at 700 to 900 °C. This is considerably higher than was observed by [62Joh] and [68Dub].

Crystal Structures

A summary of crystal structure and lattice parameter data for the pure elements is given in Table 2.

Thermodynamics

The temperature dependence of the activity coefficient of Be in the Zn solution is $\ln\gamma_{Be} = -1.842 + 6781/T \pm 0.150$ according to the emf measurements by [68Dub]. The Be-Zn phase diagram can be estimated using the excess Gibbs energy function for the liquid phase derived from γ_{Be}: $G^{ex} = X(1-X)(41677 - 5.886T)$ J/mol (Case I model). The liquidus trend given by [62Joh] (Fig. 2) leads to a similar model for the liquid phase as $G^{ex} = X(1-X)(47189 - 13.751T)$ J/mol (Case II model). The lattice stability parameters of βBe, αBe, and Zn (Table 3) have been derived from the heats of transformation given by [83Cha]. Both models generate monotectic-type phase diagrams (Fig. 3). The critical point of the liquid miscibility gap is not satisfactorily determined due to excessive extrapolation. Therefore, Fig. 1, based on the Case I model, should be regarded as qualitative. The eutectic temperature has been estimated to be 0.2 °C lower than the melting point of Zn by assuming that the eutectic composition is 99.96 at.% Zn and that the (Zn) phase has no solubility range.

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* Indicates key paper.

Acknowledgement

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Table 2 Be-Zn Crystal Structure and Lattice Parameter Data

Phase	Composition, at.% Zn	Pearson symbol	Strukturbericht designation	Space group	Prototype	Lattice parameters, nm a	c	Reference
(βBe)....	0	cI2	A2	Im3m	W	0.25515	...	[King2]
(αBe)....	0	hP2	A3	$P6_3/mmc$	Mg	0.22857	0.35839	[King1]
(Zn).....100		hP2	A3	$P6_3/mmc$	Mg	0.26644	0.49494	[King1]

Table 3 Thermodynamic Functions for the Be-Zn System (J/mol)

Lattice Stability Parameters:

$$\underline{G}^{\circ}(Be,L) = 0$$
$$\underline{G}^{\circ}(Zn,L) = 0$$
$$\underline{G}^{\circ}(Be,bcc) = -12600 + 8.067\underline{T}$$
$$\underline{G}^{\circ}(Be,cph) = -14700 + 9.428\underline{T}$$
$$\underline{G}^{\circ}(Zn,cph) = -7320 + 10.567\underline{T}$$

Excess Gibbs Energy of Mixing for the Liquid Phase:

$$\underline{G}^{ex} = \underline{X}(1-\underline{X})(41677 - 5.886\underline{T}) \quad \text{from [68Dub]} \quad \text{(Case I model)}$$
$$\underline{G}^{ex} = \underline{X}(1-\underline{X})(47189 - 13.751\underline{T}) \quad \text{from [62Joh]} \quad \text{(Case II model)}$$

$\underline{X}$: mole fraction of Be or Zn. $\underline{T}$: Temperature in K.

Be-Zn figure captions

Fig. 1 Assessed Be-Zn Phase Diagram

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Fig. 2 L/[L + (αBe)] Liquidus in Terms of ln$\underline{X}$ as a Function of 1/$\underline{T}$

$\underline{X}$: Mole fraction of Be. $\underline{T}$: Temprature in K

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Fig. 3 Comparison of the Calculated Be-Zn Phase Diagram

Assumed thermodynamic parameters are as given in Table 3.
———— = Case I, ——— . ———.——— = Case II.

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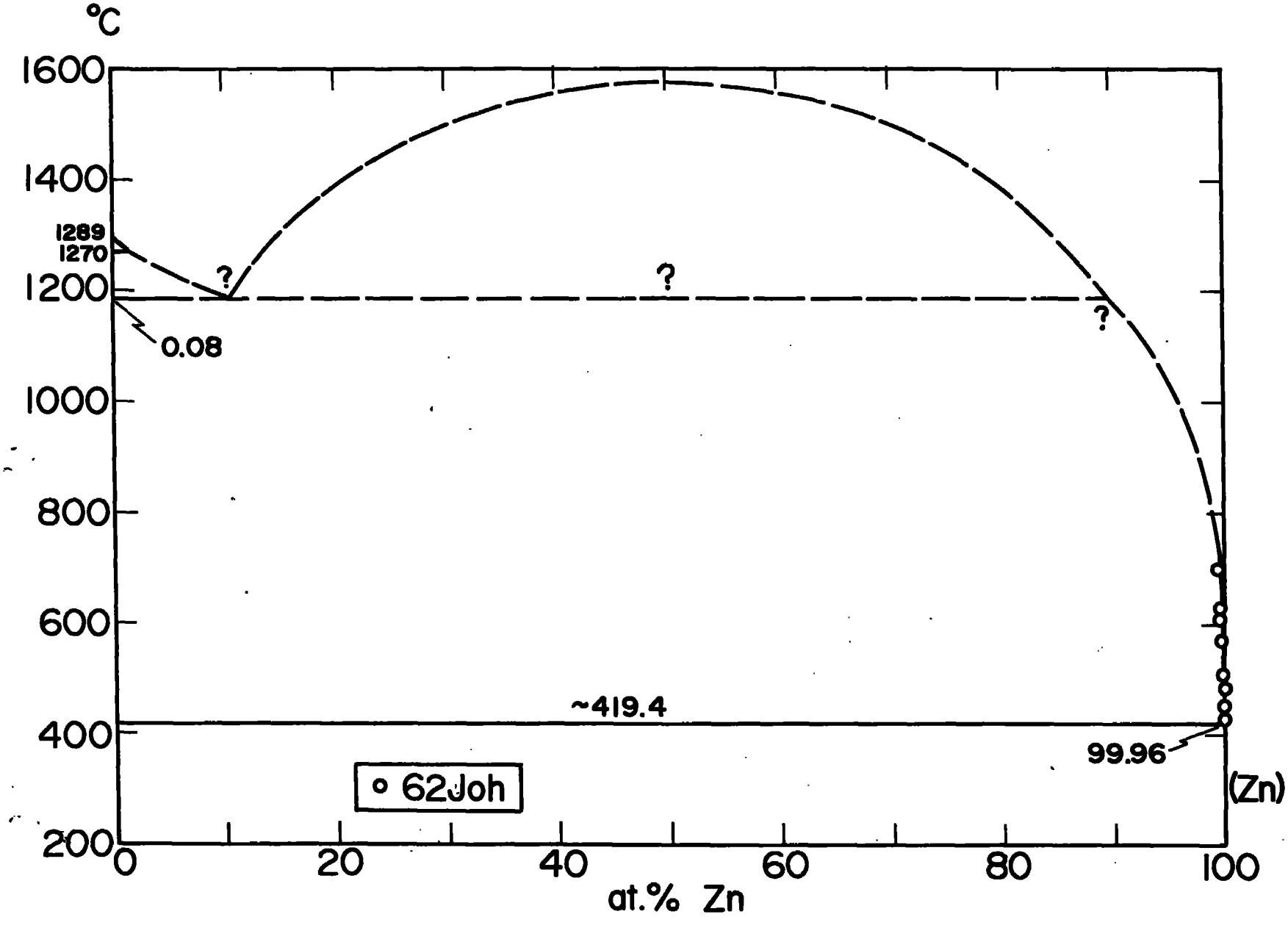
°C
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?
?
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(Zn)
o 62Joh
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20
40
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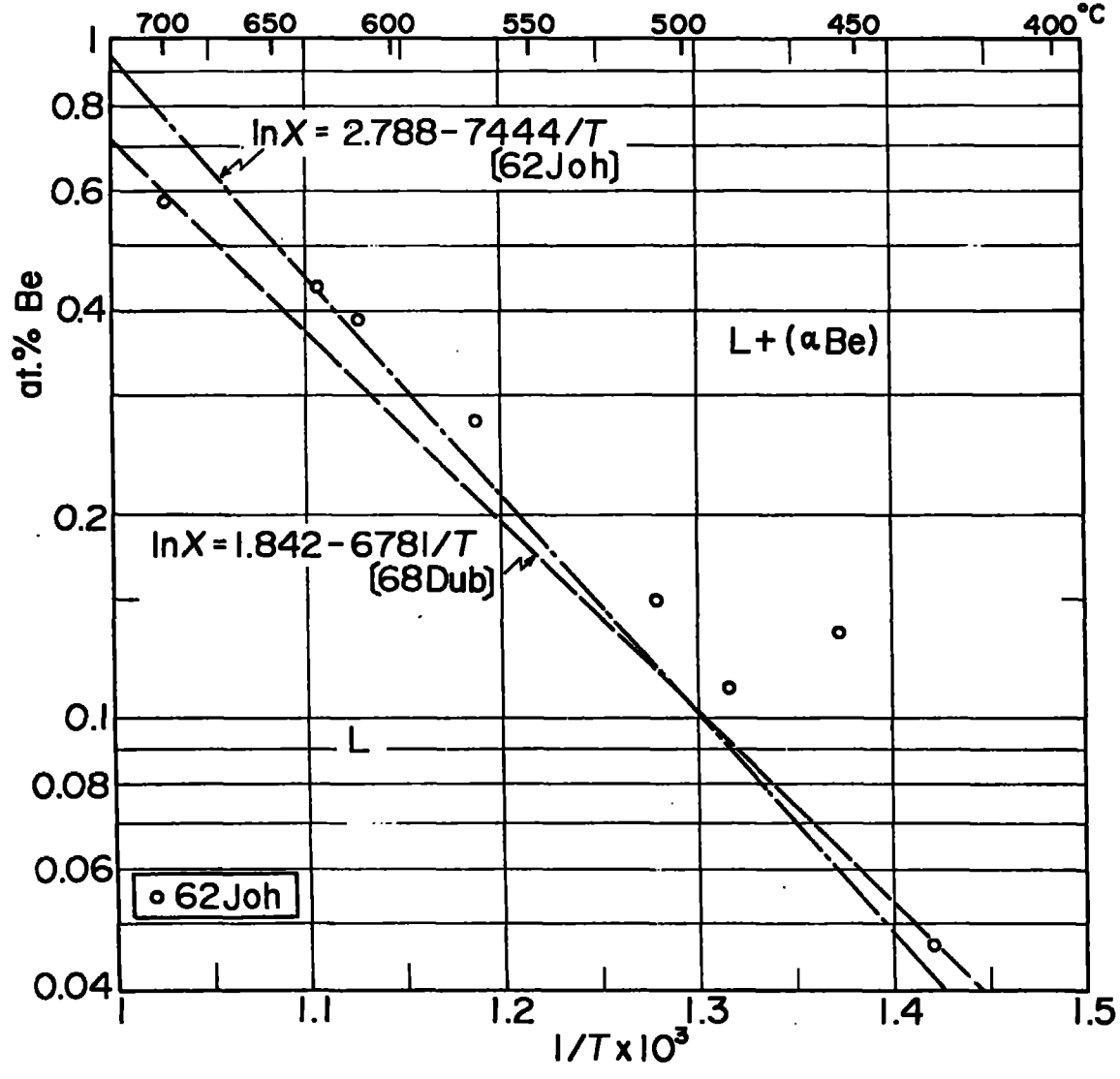
80
100
at.% Zn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400°C
1
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0.6
0.4
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0.08
0.06
0.04
at.% Be
lnX = 2.788 - 7444/T
(62Joh)
L + (αBe)
lnX = 1.842 - 6781/T
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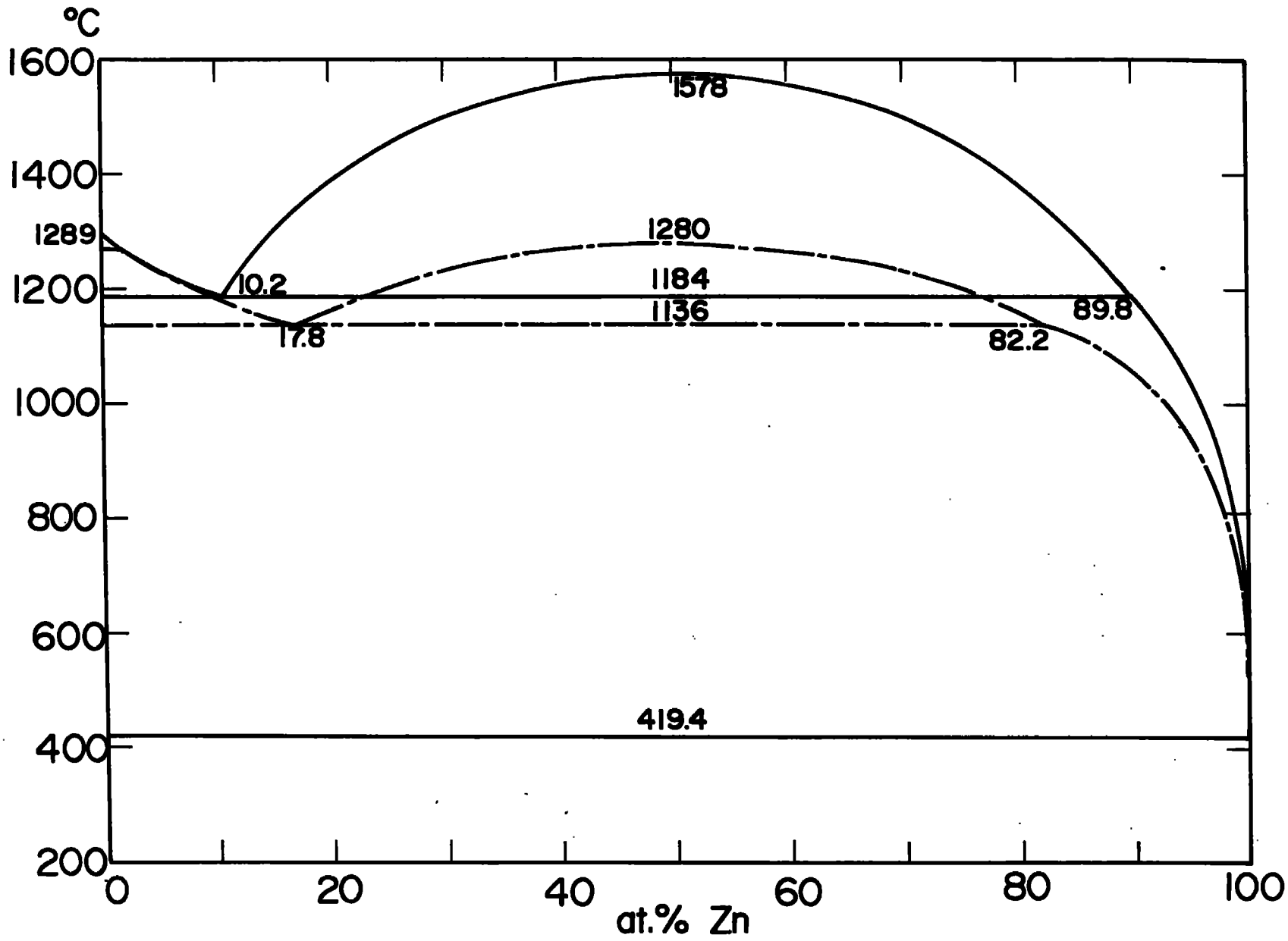
1/T x 10³


°C
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10.2
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89.8
17.8
82.2
419.4
0
20
40
60
80
100
at.% Zn